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(54) PROCESS AND APPARATUS FOR DYEING A CONTINUOUSLY MOVING FILAMENT

(71) We, VEB WTZ TRIKOTAGEN UND STRÜMPFE, of 8, Pestalozzistrasse, 9102 Limbach-Oberfrohna, German Democratic Republic, a Corporation organised under the laws of the German Democratic Republic,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with a process for dyeing a continuously moving filament, as well as with apparatus for carrying out this process.

In practice, chemical filaments, especially texturised polyamide and polyester filaments, are dyed in various forms of make up according to the requirements demanded of the finished products by the industries using the filaments. To a preponderant extent, the texturised filaments are thereby either dyed in in the form of skeins or on rigid or flexible spools or also, without the use of spools, as a muff on a cross-spool dyeing apparatus.

However, this dyeing process necessitates additional preparatory and finishing work, the individual working steps being carried out discontinuously, which results in a laborious method of working.

The size of the dyeing batches depends upon the capacity of the available dyeing apparatus. Furthermore, due to the different spool or winding diameters which cannot always be influenced, there is a danger of unequal dyeings.

For overcoming these disadvantages, attempts have already been made by synthetic fibre manufacturers to produce spin-dyed synthetic filaments in order to be able to omit the dyeing process which previously took place after the texturising of the synthetic filaments.

However, a large-scale use of this process is restricted by the limited number of available dyestuffs, the high change-over costs when using a different dyestuff and the unusually large dye batches per colour shade.

Consequently, attempts have already been made to develop continuous dyeing processes for filament batches which, however, in the case of polyamide and polyester filaments, could only be carried out in isolated cases by tow dyeing and by the so-called space-dyeing technique. Due to the great technical expense involved, the application of such processes to individual filaments only brings economic advantages if they can be combined with process steps of working up the filaments suitable therefor.

For this purpose, a process is known according to which a continuous filament dyeing of synthetic filaments takes place in combination with the crimping step of false twist texturing machines. The filament is thereby, before the high twisting step, passed through an aqueous dyestuff solution and, in the highly twisted state, subjected to the brief action of hot air or vapour, the fixing of the mechanical deformation of the filament and the fixing of the dyestuff thereby taking place simultaneously.

As a result of continuing development, however, the filament draw-off speeds on texturising machines have been continuously increased in recent years so that the residence time of the filament in the hot zone has been reduced to less than a second. However, this time is not sufficient for a satisfactory fixing of the dyestuffs which, as a rule, necessitates a period of treatment of up to 30 seconds. Admittedly, it is known, by means of hydrophilic solvents and under thermoplastic conditions of the filaments, to bring about a reduction of the minimum contact time for dyeing to 5 seconds but even these process times are too long and also too variable in order to base thereon a dyeing process combined with a false twist texturising.

In the case of insufficient dyestuff fixing, either a post-vaporisation or a post-washing with drying would be necessary. In this case, the technical expense for the simultaneous crimping and dyeing of an individual filament would increase to such an extent that the economic advantages of such a process integration would again be lost.

Consequently, further developments in the field of dyeing continuously moving filaments have been directed towards dyeing in combination with the texturising according to the stuffing box principle. In this case, a certain residence time of the filament in the stuffing box is available which, with the provision of appropriate mechanical apparatus, can be utilised for the dyeing and fixing processes. Thus, for example, apparatus is known in which the filament first passes through a trough containing a dyebath and the dyestuff taken up is fixed on the filament in the following stuffing box by an inflowing fixing medium in the form of hot air or vapour.

Furthermore, processes and apparatus are known in which, by various arrangements of the dyeing apparatus, as well as other additional means, the application of the dyestuff to the filaments takes place either in the stuffing box itself or subsequent thereto.

The above-mentioned processes and apparatus all suffer from the disadvantage that they can only be used in conjunction with the stuffing box principle which, however, due to the middle-elastic, low bulk and comparatively coarse filaments producable according to this principle, which are only suitable for certain purposes, is of limited applicability. For the production of textured filaments of finer titre, especially for the clothing industry, it is preferable to use texturising processes according to the false twist principle.

An object of the present invention is to overcome the above-mentioned deficiences of the known processes and apparatus, especially in the case of the combination of the two process steps of dyeing and texturising.

Consequently, the problem forming the basis of the present invention is to provide a process for dyeing a continuously moving filament which, with the shortest possible residence times of the filament in the dyeing and fixing apparatus, permits, without a discontinuous post-working, a fast dyeing of good levelness and also, in combination with a texturising process according to the false twist principle under the conditions of a high-turn false twist machine, guarantees dyeing and texturising effects of good quality.

A further object of the present invention is to provide apparatus for carrying out this process.

According to the present invention, there is provided a process for dyeing a continuously moving synthetic filaments to be texturised by imparting a twist thereto, whereby the filament, before imparting the twist, is passed through a dyestuff solution, wherein a stretched synthetic filament under a predetermined constant tension or an unstretched filament or a pre-oriented unstretched filament under a predetermined constant stretching, is dosed with a dyestuff solution, optionally in conjunction with at least one hydrotropically-acting chemical, passed through a drying zone and then through a twisting and fixing zone, preferably with fixing of a twist imparted to the filament.

When the synthetic filament used is a stretched filament, it is preferably a stretched polyamide or polyester filament, when it is an unstretched filament, it is preferably an unstretched polyamide or polyester filament, and when it is a pre-oriented unstretched filament, it is preferably a pre-oriented unstretched polyamide or polyester filament.

According to a preferred embodiment of the present invention, when hydrotropically-acting chemicals are used, they can be applied to the filaments separately or together with the dyestuff solution. As hydrotropically-acting chemicals, there can be used, for example, the following: aliphatic and aromatic carboxylic acid amides, especially acetamide, chloroacetamide, propionamide or nicotinic acid amide; polyhydroxy aliphatic alcohols and aminoalcohols, especially ethylene glycol, propylene glycol, butylene glycol, triethanolamine or glycerol; aliphatic thiocarboxylic acid amides, for example thiourea or thioacetamide; phenols, especially dihydroxybenzenes, and aromatic alcohols, especially benzyl alcohol; urea and its derivatives, for example monoalkyl and dialkyl-ureas, especially ethyleneurea; or lactones, especially γbutyrolactone.

The hydrotropically-acting chemicals can be used individually or in the form of mixtures thereof.

According to a further preferred embodiment of the present invention, unstretched and pre-oriented unstretched filaments are, in the course of the dyeing and drying process, stretched up to the required stretching ratio or, in the course of the dyeing and drying process, subjected to a partial stretching and, in the region of the dyestuff fixing, subjected to a final stretching.

The partial stretching thereby preferably amounts to about 85% and the final stretching to about 15% of the required total stretching.

For carrying out the process according to the present invention, there can be used apparatus in which, between an input supply

means and a withdrawal means, there is arranged a dyeing device, for example in the form of a padding trough, as well as a drying means, for example in the form of a heated tube, between which is present a means for removing excess dye, the withdrawal means being followed by a twisting zone and a fixing zone in the form of a heated tube and then by a removal means.

When the drying means is in the form of a heated tube, it is preferably formed by a radiation or convection heated body.

The means for removing excess dye consists, for example, of a straight, curved or lightly coiled tubular body adapted to surround the filament which extends into or above the padding trough or some other device for the application of the dyestuff, extending up to the drying means. The internal diameter of the tubular body is not substantially greater than the diameter of the filament to be treated.

When the fixing zone is in the form of a heated tube, it is preferably the heated body of a texturising machine.

The input supply means, the withdrawal means and the removal means can run, with regard to one another, at selectively different speeds.

According to the process of the present invention, even residence times in the fixing zone of 1 second and less are sufficient to achieve a completely fixed dyeing with a good levelness, without an after-washing being necessary. These extraordinarily short residence times take into account the capacity parameters of modern false twist machines so that the synthetic filaments leave the fixing zone fully dyed and fixed. The apparatus can be readily operated.

The present invention will now be described in more detail on the basis of a specific embodiment and with reference to the accompanying drawing, in which there is schematically illustrated apparatus according to the present invention.

Referring now to the accompanying drawing, a filament (1) is withdrawn by means of an input supply means (2) from a supply spool (3) and passed through a padding trough (4). Upon leaving the padding trough (4), the filament (1) passes through means (5) for removing excess dye, as well as a subsequent heated tube (6) and then passes into the following withdrawal means (7). After the filament (1) has left the withdrawal means (7), it passes through a second heated tube (8) and is finally drawn off by removal means (9) and applied to a suitable thread carrier (10). The rate of revolution of the input supply means (2) and of the withdrawal means (7) can be regulated and can be so controlled that the filament (1), during its passage through the padding trough (4), the means (5) for removing excess dye and the heated tube (6) is kept under a predetermined constant tension or under a predetermined constant stretch.

In the case of a stretched synthetic filament, the tension can be about 2 to 6%

In the case of unstretched and pre-oriented unstretched synthetic filaments, the stretching can be up to about 85% of the desired final stretching ratio.

In the same way, the rate of revolution of the removal means (9) and the rate of revolution of the withdrawal means (7) can be regulated in order possibly to stress or stretch the filament (1) to a certain degree also in the region of the second heated tube (8).

The padding trough (4) contains an aqueous, weakly acidic dyestuff solution of conventional, known dispersion, acid or metal complex dyestuffs.

Depending upon the state of the filament (1) fed in, i.e. stretched, unstretched or pre-oriented unstretched, there are used, in addition to the dyestuff solution, hydrotropically-acting chemicals as so-called diffusion accelerators.

The application of these chemicals, the action of which depends upon the nature of the polymer, can take place either together wih the dyestuff solution or separately therefrom in a special padding process. The concentration thereof depends upon the colour depth to be achieved, the degree of stretching and the titre of the filament (1). Unstretched and pre-oriented unstretched synthetic filaments require, because of their smaller degree of crystallinity, in the same way as synthetic filaments of low titre, a lower concentration of these chemicals.

As diffusion-accelerating chemicals for polyamide and polyester filaments, there are preferably used hydrotropically-acting substances with a sufficient degree of water-solubility or dispersability, either alone or preferably in admixture with one another. These chemicals, already described in detail above, which boil above 180°C., are hydrogen bridge formers and, due to their pacifying action on the filament, accelerate the diffusion of the dyestuff molecules. The solubility of all classes of dyestuffs is also improved by the presence of these hydrotropically-acting substances.

Since, according to this process, all classes of dyestuffs diffuse in the same manner, the effectiveness of these chemicals is, to the widest possible extent, independent of the dyestuffs used for a filament.

In order to ensure a non-affinitive (i.e. non-reactive) padding of the dyestuff on to the filaments, the padding bath temperature is preferably kept at ambient temperature.

Upon passage of the filament (1) through the heated tube (6), there takes place, at a temperature of about 150°C. for polyamide

filaments and of about 180°C. for polyester filaments, a drying of the dyestuff applied to the filament (1). Upon passage through the second heated tube (8), there takes place at a temperature of 100 to 150°C. for polyamide filaments and of 180 to 220°C. for polyester filaments, a fixing which, in the case of a combination of the two process steps, dyeing and texturising, is simultaneously undertaken with the fixing of the twist imparted to the filament. In this case, the heated body (8') of the false twist texturising machine takes over the function of the second heated tube (8) and the withdrawal means (7), as well as the removal means (9) is formed by the means (7') and (9') of the texturising machine. Furthermore, a false twist pin or spindle is arranged between the body (8') and the means (9') (See the accompanying drawing).

Dyed, texturised and fixed filaments are applied to a thread carrier (10'), whereas dyed but not exturised filaments are applied to a thread carrier (10") for temporary storage prior to subsequent texturising.

The means (5) for removing excess dye present between the padding trough (4) and the heated tube (6), removes excess dyestuff solution from the filament (1). The means (5) can be a tubular body which extends from the padding trough (4) up to the heated tube (6) and either runs straight or, for increasing the removal effect, is curved or is lightly coiled.

It is advantageous for the tubular body to extend into the padding trough (4) so that the filament (1) already in the dyestuff solution passes inside the tubular body and is enclosed thereby until it reaches the heated tube (6).

It is also possible for the tubular body to commence at a certain distance above the padding trough (4) and in the free region, with the help of a suitable filament guiding means, touchingly to pass the filament (1) coming from the supply spool (3), before its entry into the dyestuff solution, with the filament (1) emerging from the dyestuff solution.

It has also proved to be desirable to provide the device for the application of the dyestuff, i.e. in the present case the padding trough (4), with a (not shown) known type of filling level regulating means in order to ensure a constant level of the dyebath during the dyeing process.

The following Examples, which are given for the purpose of illustrating the present invention, describe the dyeing process in combination with a texturising of the filament according to the false twist principle:

Example 1.

At a withdrawal rate of 60.0 metres/minute and 3200 twists per metre, stretched polyamide filament 100 dtex f24 is dyed and texturised.

The rate of rotation of the withdrawal means (7') is so adapted to the rate of rotation of the input supply means (2) that the filament passes through the dyeing and drying device with a tension of 3%. The drying device comprises a heated tube (6), the temperature of which is about 150°C. Fixing takes place in the heated body (8') of a false twist texturising machine at a temperature of 145°C. The padding bath used contains 12.0 g./litre "Nylosan" blue N-GL, 3.0 g./litre concentrate W 50 (a detergent of the sodium alkane sulphonate type), 2.0 g./litre 98% acetic acid, 40.0 g/litre benzyl alcohol and 20.0 g./litre propionamide. ("Nylosan" is a Registered Trade Mark.)

There is obtained blue coloured polyamide texturised filament of average ductility which, without a post-washing, has the following fastnesses, determined according to the standard procedures of the European Convention for testing fastnesses: wash fastness *a* 4, fastness to perspiration 4 and fastness to rubbing 5.

Example 2.

Stretched polyester filament 150 dtex f48 is dyed and texturised at a withdrawal rate of 99.0 metres/minute and 2120 twists per metre.

The tension between the input supply means (2) and the withdrawal means (7') is predetermined to be 2%. The temperature of the heated tube (6) is about 180°C. and that of the heated body (8') of the false twist machine 210°C. The padding bath used contains: 6.6 g./litre "Foron" blue S-BGL, 3.0 g./litre Concentrate W 50, 2,0 g./litre 98% acetic acid, 40.0 g./litre benzyl alcohol and 20.0 g./litre propionamide. ("Foran" is a Registered Trade Mark.)

The so dyed and texturised polyester filament is of average ductility and has a medium blue colour. The fastness to washing *a*, as well as the fastnesses to perspiration and rubbing, have the value 4.

Example 3.

An unstretched polyamide filament 68 dtex f12 is dyed and texturised at a withdrawal rate of 86.5 metres/minute and 3300 twists per metre. The unstretched filament is stretched between the input supply means (2) and the withdrawal means (7'), i.e. in the region of the dyeing and drying device, up to a stretch ratio of 1:2.6. The temperature of the heated tube (6) is 150°C. Upon passage through the false twist device of the texturising machine, there takes place, between the withdrawal means (7') and the removal means (9'), a final stretching of the filament (1) up to the required total stretch ratio which, in the present case, is up to the ratio of 1:3.2. The temperature of the heated body (8') of the texturising machine is 135°C. The padding bath, which does

not contain hydrotropically-acting chemicals, has the following composition: 15.0 g/litre Nylosan orange N-RL, 3.0 g./litre Concentrate W 50 and 2.0 g./litre 98% acetic acid.

There is thus obtained an orange-dyed polyamide texturised filament of average ductility with a value of 4 for wash, perspiration and rubbing fastnesses.

In all of the above Examples, the degree of dyestuff fixing is 100%.

WHAT WE CLAIM IS:—

1. Process for dyeing a continuously moving synthetic filament to be texturised by imparting a twist thereto, whereby the filament, before imparting the twist, is passed through a dyestuff solution, wherein a stretched synthetic filament under a predetermined constant tension or an unstretched filament or a pre-oriented unstretched filament under a predetermined constant stretching, is dosed with a dyestuff solution, passed through a drying zone and then through a twisting and fixing zone.

2. Process according to claim 1, wherein fixing of a twist imparted to the filament takes place simultaneously with fixing of the dyestuff.

3. Process according to claim 1 or 2, wherein at least one hydrotropically-acting chemical is applied to the filament separately or together with the dyestuff solution.

4. Process according to claim 3, wherein the hydrotropically-acting chemical is an aliphatic or aromatic carboxylic acid amide, a polyhydroxy aliphatic alcohol or amino-alcohol, an aliphatic thiocarboxylic acid amide, a phenol, an aromatic alcohol, urea, a urea derivative or a lactone.

5. Process according to claim 4, wherein the hydrotropically-acting chemical is acetamide, chloroacetamide, propionamide, nicotinic acid amide, ethylene glycol, propylene glycol, triethanolamine, glycerol, butylene glycol, thiourea, thioacetamide, a dihydroxybenzene, benzyl alcohol, a mono- or dialkyl-urea or γ-butyrolactone.

6. Process according to any of the preceding claims, wherein the unstretched and the pre-oriented unstretched filament is, in the course of the dyeing and drying process, stretched up to the required stretching ratio.

7. Process according to any of claims 1 to 5, wherein the unstretched and the pre-oriented unstretched filament is, in the course of the dyeing and drying process, subjected to a partial stretching and in the region of the dyestuff fixing to a final stretching.

8. Process according to claim 7, wherein the partial stretching amounts to about 85% and the final stretching to about 15% of the required total stretching.

9. Process according to claim 1 for dyeing a continuously moving filament, substantially as hereinbefore described and exemplified and with reference to the accompanying drawing.

10. Apparatus for carrying out the process according to any of claims 1 to 9, wherein between an input supply means and a withdrawal means, there is arranged a dyeing device, as well as a drying means, between which is present a means for removing excess dye, the withdrawal means being followed by a twisting zone and a fixing zone in the form of a heated tube and thereafter by a removal means.

11. Apparatus according to claim 10, wherein the dyeing device is in the form of a padding trough.

12. Apparatus according to claim 10 and 11, wherein the drying means is in the form of a heated tube.

13. Apparatus according to claim 12, wherein the heated tube constituting the drying means is formed by a radiation or convection heating body.

14. Apparatus according to any of claims 10 to 13, wherein the means for removing excess dye comprises a straight, curved or lightly coiled tubular body adapted to surround the filament.

15. Apparatus according to claim 14, wherein the tubular body extends into or above the dyeing device, extending up to the drying means.

16. Apparatus according to claim 14 or 15, wherein the internal diameter of the tubular body is not substantially greater than the diameter of the filament to be treated.

17. Apparatus according to any of claims 10 to 16, wherein the heated tube constituting the fixing zone is the heated body of a texturising machine.

18. Apparatus according to any of claims 10 to 17, wherein the input supply means, the withdrawal means and the removal means run with selectively different speeds to one another.

19. Apparatus according to any of claims 10 to 18, substantially as hereinbefore described and exemplified and with reference to the accompanying drawing.

20. Filaments, whenever dyed by the process according to any of claims 1 to 9.

21. Filaments, whenever dyed with the apparatus according to any of claims 10 to 19.

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1486935 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*